Cryptosporidiosis and hotel swimming pools – a multifaceted challenge

R.Y. Cartwright* and J.S. Colbourne**

* MicroDiagnostics (UK) Ltd, 55 Holford Road, Merrow, Guildford GU1 2QE, UK (E-mail:*cartwright@dial.pipex.com*)

** Thames Water Utilities, Research & Technology, Spencer House, Manor Farm Road, Reading RG2 0JN, UK (E-mail: *Jeni.Colbourne@Thameswater.co.uk*)

Abstract An outbreak of *Cryptosporidium* infection affected at least 172 British tourists who had stayed at a family hotel in a Mediterranean resort. Recognition of the outbreak came from non-official sources. In the absence of any meaningful investigations by the public health authorities of both the countries, a tour operator undertook an investigation. The epidemiological studies were restricted but it was concluded that the outbreak was associated with contaminated swimming pool water at the hotel. The initial source of contamination was most probably a hotel guest who was excreting *Cryptosporidium* oocysts. Examination of the water treatment system revealed some deficiencies in the sand filters but the effect on the course of the outbreak could not be determined. Although the media in the filters was thoroughly cleaned and the filters refreshed, oocysts could still be detected in pool water and further cases occurred. The challenges of an outbreak involving more than one country and the measures necessary to reduce the risks of cryptosporidium infections associated with hotel swimming pools are discussed.

Keywords *Cryptosporidium*; hotel; swimming pool; water

Introduction

Water-associated *Cryptosporidium* infections have only relatively recently been recognised. The first recorded outbreak occurred in 1984 in Braun Station, Texas affecting 117 persons. (Craun *et al*., 1998). Subsequently there have been outbreaks reported throughout the world associated with drinking water supplies. A number of countries have enacted legislation to reduce the risk of cryptosporidiosis associated with drinking water with the emphasis being on the effective design and operation of water treatment plants to remove *Cryptosporidium* oocysts and monitoring. Oocysts are not susceptible to drinking water chlorination practice so the adequacy of filtration is seen as very important. In some countries membrane filters as opposed to sand filters have been installed.

The first reported UK *Cryptosporidium* outbreak linked to swimming was in 1988. (Joce *et al*., 1991). In the investigations it was found that the pool water was contaminated with sewage and in the first American outbreak (Anon., 1990) there were problems with the pool filters. Sporadic swimming pool associated outbreaks have continued to be reported ever since. (Sorvillo *et al*., 1992, 1994; MacKenzie *et al*., 1995, 2000; Hellard *et al*., 2000; Stafford *et al*., 2000).

The UK regulator for drinking water (Drinking Water Inspectorate) was sufficiently concerned about swimming pools as a significant source of cryptosporidiosis to commission a review of swimming pool associated cases in the UK (Chalmers, 2000). Eighteen outbreaks were identified as occurring between 1989 and 1999 seven during 1999. The outbreaks were associated with both well managed and poorly managed pools.

Most recorded outbreaks have been associated with municipal or public pools. There have been few reports of cryptosporidiosis linked to hotel swimming pools in spite of the very large numbers of tourists who use hotel pools intensively. In part this will relate to the

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illnesses not being diagnosed until after the tourist returns home. Additionally the surveillance system of the home country must then be able to recognise that sporadic cases reported from different parts of the country could have a common source in another country.

This report describes a hotel swimming pool associated outbreak of cryptosporidiosis in a popular Mediterranean resort and discusses some of the learning points.

Method – the outbreak investigation

The outbreak was amongst tourists staying in a 1,100 bedded hotel in a Mediterranean resort. Most guests in the hotel had travelled with one British tour operator but some guests were from other European countries. The exact number of guests infected could not be determined but information was received on 172 infected guests. All these cases were amongst British tourists. There were no reports of infection in other nationalities staying in the hotel.

In late July 2000, a British consumer association notified a tour operator that there were an increasing number of tourists, who had recently stayed at one Mediterranean resort hotel, who were diagnosed as suffering from a *Cryptosporidium* infection. Basic details such as the time of onset of the symptoms were unavailable. A few of these cases had been reported by the patient's doctor to the Public Health Laboratory Service Communicable Disease Surveillance Centre (CDSC) but the number was small and insufficient information was available to link the cases to a geographical source and alert as to a possible outbreak. More cases were reported subsequently from the same, but no other hotel. An assumption was made that the infections could have been acquired while the tourists were staying in the hotel. The absence of cases in other hotels in the same resort suggested that the local water supply was unlikely to be the source of infection, thus, suspicion fell on the swimming pool. The Department of Health in London informed the Ministry of Health in the country of the hotel of these suspicions.

From information that became available subsequently some hotel guests had suffered from cryptosporidium during May, June and early July. Due to the sharp increase in cases in late July the tour operator became aware of the problem in August when it was arranged for a pool expert to visit the hotel and to inspect the pool water treatment plant. Meanwhile guests were advised not to swim in the pool.

Results – pool inspection findings

The hotel had three pools – a small (12–15 m^3) splash pool that was filled and emptied daily, a large (700 m^3) leisure pool of irregular shape with an artificial beach, and the main swimming pool (1,400 m^3) again of irregular shape.

There was a separate water treatment plant for each pool. At the time of inspection there were no written procedures for the maintenance of the pool or its water treatment systems.

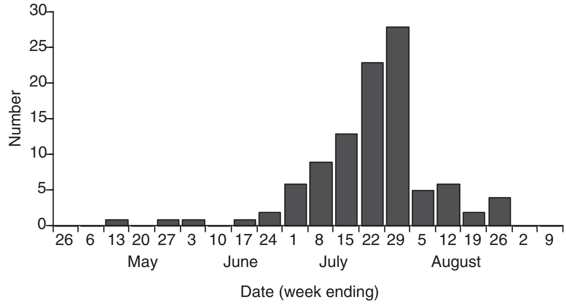

Figure 1 Date of onset of symptoms

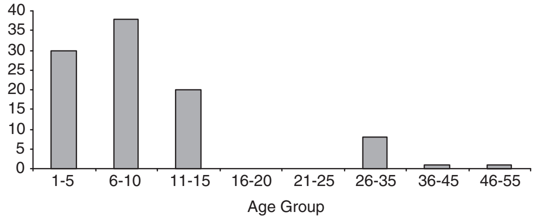

Figure 2 Age structure of confirmed cases. The majority of those infected were children.

A few days later an operating manual and technical details of the filters were obtained. There was no policy for the management and recording of faecal accidents in the pools.

The small splash pool was empty when the expert arrived at the hotel, therefore, it could not be sampled. The treatment plant comprised a sand filter without any chemical dosing system therefore pH and chlorine control was achieved by manual means.

There were three sand filters serving the two larger pools. The filter manual stated that the purpose of these filters was *"to eliminate suspended particles from the circulating water, thus improving the clarity of the water"*. There had been no complaints from guests or staff at the hotel suggesting the water was cloudy so from this perspective the filters were working in accordance with the specification.

To inspect the filters it was necessary to unbolt and remove the top of the filter structure, there being no inspection portholes. On removal there was visual evidence of the filters being in poor condition e.g. major cracks in the surface (Figure 3). Samples of sand taken from approximately 0.5 metres depth were very sticky and dirty. All these observations indicated a history of ineffective filter backwashing and/or overdosing with coagulant. *Cryptosporidium* oocysts (8 in 5 grams) were detected in samples of the sand. 10 litre samples of water from the pools had oocysts detectable at levels up to 2.2 per litre. The analyses were undertaken in a DWI audited and approved water testing laboratory in England.

The coagulant in use was, polyhydroxychlorosulfate of aluminium. The dosing point had been changed recently as previously it had been immediately before the filters. A fully automatic control system was installed for pH correction and chlorination. Records showed that these had been working according to the specification.

After inspection the filters were cleaned. First they were filled with a solution of stabilised chlorine dioxide and allowed to stand for 24 hours. They were then drained, refilled with fresh water, thoroughly backwashed and rested.

Figure 3 The surface of the sand filter showing major fissuring

Three sets (2 × 10 litres per set) of pool water samples were collected over a 48-hour period. Oocysts were not detected in any of these samples. At this stage guests were allowed to resume using the pool but samples continued to be collected over the next week. Oocysts became detectable in the pool water again at levels of 0.1–14.5 oocysts per litre. At this point in time, one week after the pool reopened, new cases amongst guests who had stayed at the hotel previously and returned home were still being reported. The British tour operator withdrew clients from the hotel. Other operators continued to send clients to the hotel and amongst these guests there were no reported cases of cryptosporidiosis.

Discussion

This outbreak was associated with a holiday hotel situated in a different country from the homes of the people who were affected and this raises a number of interesting learning points regarding the surveillance of travel related communicable diseases, outbreak response and investigation procedures and water treatment design and management in hotel leisure facilities.

Previously reported swimming pool outbreaks have been linked to municipal pools in the home country of those affected. There are significant differences in the design and usage of municipal and hotel pools. Most municipal pools are 25 m long by 15 m wide (rectangular in shape) and between 0.9 m and 3.0 m deep, being built for teaching, training and local competition purposes. By contrast hotel pools are leisure only facilities, these are usually shallow with several curved sections interconnected by narrow deeper channels.

Municipal pools are in use every day for up to 18 hours with individuals swimming for half or one hour sessions. Hotel pool use is less structured, there is less control over bathing density at any given time and individuals may swim for several hours in a day. Holidaymakers, especially children, can be exposed to a hotel pool for over 20 hours in a week, compared to typical municipal pool use of 1 hour a week. An additional factor is that holiday hotels are nearly always in another community than the home environment, often in other countries leading to exposure to a different diet and water supply from normal.

The recognition of cryptosporidiosis relies on the laboratory examination of a faecal specimen. In some laboratories the routine examination of faecal specimens does not include examination for *Cryptosporidium* oocysts unless there are specific indications. *Cryptosporidium* infections are not regarded as a common cause of diarrhoea in returning holidaymakers. This may explain why no infections were reported in non-British tourists in this outbreak. The onset of the symptoms may occur during the holiday or after return home, the average incubation period of cryptosporidiosis being seven days. If diarrhoea commenced during the holiday, it would most likely be attributed to travellers' diarrhoea. In such cases it is unusual for any faecal laboratory tests to be undertaken in holiday resorts (unless the tourist requires hospital admission). If the symptoms persist and correct diagnosis is made on return home, notification to a national surveillance system will depend on the country. In the UK diagnosing laboratories are encouraged to report all cases in which oocysts are identified. This notification may or may not include details of any recent travel. The likelihood of an outbreak associated with a foreign hotel being recognised by national surveillance systems is unlikely.

In this outbreak, the outbreak was recognised initially by a consumer organisation that had received reports from affected tourists. This form of notification, whilst alerting to the outbreak, created problems with verification of the facts very difficult. For example, it was not possible to carry out a normal, epidemiological study e.g. full descriptive study or a case control study. No epidemiological study was undertaken by either the home country or hotel resort health agencies. The onus was upon the tour operator to investigate and secure information by the best available means.

In the UK, public health officials usually undertake a case control study as part of the investigation of suspected swimming pool outbreaks.

This outbreak raises the question of the role of unofficial surveillance systems and the actions that should, or could, be taken if an outbreak is suspected. Particular constraints on an outbreak investigation are when tourists initiate legal action and when the absence of identifiable resources for an international investigation since health department budget priorities are for the local communities they serve.

Tour operators within Europe cannot put their reliance wholly on local or national health agencies since under the EC Package Travel, Package Holidays and Package Tours Directive (Council Directive, 1990) the tour operator is liable for all aspects of the package, including those supplied by a third party. This means that tour operators are liable for any deficiencies in the swimming pool that might result in *Cryptosporidium* infections in bathers.

Although there was a lack of good epidemiological evidence, it is highly likely the swimming pool in the hotel was involved in this outbreak. There was no evidence to suggest the source was the drinking water supply in the resort, nor was there evidence of another source in the resort but beyond the confines of the hotel. The finding of oocysts in both the filter sand and several pool water samples demonstrated that the organism was present in the hotel environment before and during the investigation.

The most plausible explanation of the outbreak is that oocysts were introduced into the pool by an infected bather (or bathers), either as a result of a faecal accident or due to peri-anal skin contamination. *Cryptosporidium* can be transmitted via the faecal oral route directly between people, therefore, the pool may not have been the primary source of the outbreak rather it became contaminated as a consequence of infection spreading amongst the guests. Undoubtedly, repeated contamination of the pool water would have been inevitable and repetitive once the outbreak was under way. The amount of faeces required to contaminate the large pool (volume 1,400 cubic metres or 1.4×10^6 litres) to a level of the order of 20 oocysts per 10 litres (the highest numbers found in the pool) is as little as 1–2 grams (faeces may contain 10^6 oocysts per gram during the acute phase of illness).

In most hotels, bathers are encouraged to shower before entering the pool but the effectiveness of this advice given to guests is unknown. The British Pool Water Treatment Advisory Group and the Institute of Sport and Recreation Management have issued guidance on the prevention of swimming pool *Cryptosporidium* infections (2001). Those who are ill and suffering from diarrhoea are discouraged from swimming. Babies under six months are discouraged from using pools and for those children who are older but still in nappies it is suggested they should wear special protective swimming trunks. If there should be a faecal accident policy, solid faeces should be scooped out straightaway. Should there be a diarrhoea accident the pool should be cleared immediately, the pool vacuumed and swept. The pool should remain closed for six turnover cycles of the pool. This may take 1–2 days in a large complex pool.

Such advice is sound and for the most part can be implemented by a motivated, well resourced, municipal pool management team but the same is not true for a large busy family holiday hotel.

The number of oocysts necessary for an infection to occur in humans is thought to be as low as 9–1,000 viable (living) oocysts. These figures were obtained from human volunteer studies (DuPont *et al*., 1995) and (Okhuysen *et al*., 1999). The infective dose varies between strains of *Cryptosporidium*. Studies have also shown that immunity levels affect the minimum required dose. In persons who have previously exposed to *Cryptosporidium*, they may develop an immunity that will in part protect them from an infection. This means that they may drink contaminated water and not develop a clinical infection. The same water drunk by a person not previously exposed and not immune will be more likely to result in infection (Chappell *et al.*, 1999). The age group with the highest incidence of cryptosporidiosis in the UK was and remains children, aged 1–4 years (Badenoch, 1990) and this preponderance of infections in young children was seen in this hotel outbreak. Children tend to spend longer periods of time in a swimming pool than adults and also attend on a more regular basis, increasing their exposure. It is possible also that children ingest larger volumes of water than adults and they may be more susceptible through lack of immunity. In this outbreak it wasn't possible to determine when the pool contamination occurred. In a few cases the onset of symptoms was in May and early June but the outbreak curve did not begin to rise until late June and July.

The hotel and the pool had been subject to routine hygiene checks during the early summer but these would not have detected the problem with the filters. Records showed that chlorination, pH control and water clarity all were within acceptable limits.

Filter investigations require specialist knowledge. In this investigation, by asking appropriate questions if the hotel engineer operational deficiencies were evident; however without an operations and maintenance (O & M) manual this understanding of the operating characteristics of the treatment plant would not have been available to the hotel engineer previously. Even when the manual was obtained and studied it only pointed to water clarity as the function of the filters. Whilst conventional pool filters are not designed to remove oocysts they can do so if they are well maintained, with particular attention being paid to backwashing regimes and coagulant dosing arrangements. These aspects of operation require for there to be inspection ports and easy access and this was not the case in this instance. Once access to the filters was achieved, defects were evident including fissures in the sand beds and missing or broken diffusers. Visual examination of the sand revealed that it was sticky and dirty and microscopic examination showed the presence of oocysts. The integrity of the filters was therefore in question. Inspections at hotels in other countries have suggested that the lack of O & M manuals and the absence of filter inspection ports are common. Coagulant dosing may, or may not, be part of the original design or added at a later stage and there generally hotel engineers/maintenance staff have little knowledge of the function of coagulation dosing. In this case coagulant was being dosed but it was only during a routine check in July that it was noticed that the dosing point was too close to the filters for adequate flocculation to occur. Almost certainly this design fault contributed to the poor condition of the filter sand beds, making backwashing less effective. A lack of care in opening and closing valves would have introduced shock waves and further impeded operational performance of the filters.

Although various operational deficiencies were identified in the investigation it has not been possible to quantify their effect, if any, on the course of this outbreak. If the pool water had been heavily contaminated in a single incident e.g. faecal accident, the other bathers could have been infected at that time and before the treatment plant could have been expected to remove the oocysts even if its operation had been optimised. The time needed for all the pool water to be filtered couldn't be determined accurately as the hydrodynamics of the pool were not specified in the manual. Since the filters were in varying conditions of cleanliness, water from some parts of the pool most probably passed through the filters at much lower frequencies than water from other parts. Due to the presence of cracks in the sand bed, some water would not have received any effective filtration at all.

In all swimming pool outbreaks there is always pressure to reopen the pool as soon as possible. In this outbreak there was both political and local guest pressures on the hotel management to reopen the pool as soon as the filters had been cleaned. In UK municipal pool outbreaks, local health agencies have tended to follow the operational rule of thumb originally developed by the water industry for drinking water supply microbiological contamination incidents, that is after remediation, two successive sets of samples are free from contamination, and epidemiological surveillance also shows the number of new cases to be declining. Although in this outbreak, sets of negative water results were obtained after cleaning, the circumstances, particularly the lack of reliable epidemiological data, suggested that testing over a more prolonged period might be necessary.

Inevitably, reappearance of oocysts in samples after the pool was reopened has resulted in much speculation as to their source. Was this due to further contamination incidents, perhaps from guests still resident in the hotel who were infected? Were there unidentified sources of pool contamination or had the cleansing of the filters not been sufficient to rid the whole pool system of oocysts? The next step in the investigation would have been to carry out hydrodynamic studies of the pool circulation but as the tour operator withdrew from the hotel at this stage, such studies were not pursued to our knowledge.

The examination of the filter sand and the pool water samples were undertaken in the UK in a laboratory accredited for this purpose, there being no laboratories in the vicinity of the hotel with the necessary experience. 10 litre samples of water were transported by air to the testing laboratory and results were generally available within 24 hours of sample collection at the hotel. It was recognised that the value of water testing and the analytical results depend on the volume of water collected and the location of the collection points. There are many sampling options, for example, in the pool near the inlets or outlets, just pre filter or just post filter, and should the pool be sampled when it is in use by bathers or should it be empty. Largely the sampling regime must be chosen to reflect the question being asked. To test the effectiveness of pool treatment and cleansing, water returning from the pool just prior to filtration and post filtration yields the most meaningful data. If on the other hand, samples are to investigate whether a pool is the source of an outbreak, then samples from the pool at a point furthest away from the treatment plant together with samples of filter sand are most helpful. In this instance, the volume of water samples was largely dictated by the limitations of the air transport. In future investigations investigators could be dispatched to the site with poolside filter concentrating equipment that would facilitate more rapid sampling, larger volumes of water could be sampled if this was felt appropriate and it would minimise transportation costs. Despite the limiting factors in this investigation, it was found that the use of a UK test laboratory with staff experienced in 24 hour, 365 days water operations was a critical factor, as this meant that results were provided very quickly guiding decisions about further sampling, water treatment optimisation and pool reopening.

Various conclusions and recommendations have been formulated following this outbreak.

1. The surveillance of travel associated infections should involve both official and unofficial communication channels.
2. The protection of the health of tourists can be improved by the active collaboration of public health departments and the tourist industry.
3. The role of pool water treatment plants, especially the filters, in the removal of *Cryptosporidium* oocysts from swimming pool water needs to be better understood and knowledge from the water industry transferred. For example, simple tests exist and could be introduced, to assess the cleanliness of filter sand and to indicate the efficiency of backwashing or coagulation. Different types of filter media may be more appropriate and backwashing could be improved, for example, combined air and water washing is far more efficient than the typical water only washing that exists in conventional pool water systems.
4. There should be a manufacturers O & M manual supplied to the operator of every swimming pool water treatment plant and this should include important pieces of

information such as the turnover time of the pool, The routine maintenance of filters should include examination of the sand or filter medium annually using the dirt test and if necessary cleaning with an agent such as chlorine dioxide. Filter media replacement with new should take place if cleaning is not effective.

5. More emphasis should be placed on bather education, especially strong advice not to use the pool when ill and not until 24 hours after the cessation of diarrhoea symptoms. Showers should be strategically placed so that bathers are encouraged to use them before entering the pool and the wastewater from showers must drain to waste and not be recycled to the pool.

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